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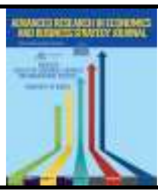

Impact of crude oil price fluctuations on consumer price index in Kenya

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ABSTRACT

This study tries to determine the impact of crude oil price fluctuations on the Consumer Price Index, CPI in Kenya, using the monthly data from 2012M1-2023M3. The Augmented Dickey-Fuller unit root test used in the analysis to test for stationarity for the series indicated that CPI and significant types of Crude oil (Kerosene, Diesel, and Super petrol) were non-stationary. The empirical analysis is carried out using cointegration by applying Johansen's multivariate approach, which reveals that not more than one cointegrating relationship holds between oil prices and CPI in Kenya. The analysis using VECM further shows that the series deviation from equilibrium to disequilibrium cannot be corrected back to equilibrium in the long run. The impulse response functions reveal that oil price shocks positively affect CPI in Kenya. As expected, the forecasted values continue to exhibit an increasing trend in the central oil type prices and CPI values in Kenya. The Jacque-Bera test for normality, ARCH-LM test for Homoscedasticity, and Portmanteau test for serial correlation were used to test for the adequacy of the Model.

Keywords: Crude Oil, Consumer Price Index, VECM, Inflation, Gross Domestic Product

JEL Codes: Q43, E31

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1. INTRODUCTION

1.1 Background of the study

The Sustainable Development Goals (SDGs) encompass energy as a critical element, mainly focusing on affordable and clean energy, to ensure universal access to sustainable, affordable, reliable, and modern energy services. Energy plays a crucial role in driving economic progress; however, its mere availability is insufficient for fostering sustainable economic development. Long-term and efficient utilization of energy resources is paramount for realizing developmental goals. Oil stands out as a primary energy source across various regions worldwide, with crude oil particularly holding a pivotal position in the commodities market. Oil prices are significantly influenced by factors such as supply and demand dynamics, production costs, available oil reserves, and market speculation driven by the attitudes of investors and countries/companies. Over the years, Kenya has relied on oil imports from various nations. Fluctuations in petroleum products and crude oil prices have cascading effects, impacting the prices of essential goods, transportation expenses, and manufacturing overheads.

The escalating cost of living is directly correlated with the rise in oil prices in oil-importing countries, thereby exerting downward pressure on consumer purchasing power and living standards. Moreover, these price fluctuations have broader ramifications, affecting vital economic indicators such as gross domestic product (GDP), exchange rates, balance of payments, and inflation rates. Oil production is typically quantified in terms of barrels per day, with oil-producing nations often yielding substantial outputs ranging from hundreds of thousands to millions of barrels daily. However, it's essential to note that the overall output is not solely determined by production capacity but is also subject to market forces. (AlArjani, Alam & Kineber, 2023)

The financial crisis of 2007/2008, followed by the subsequent great depression, had a detrimental impact on the oil and gas sector, resulting in a decline in oil and gas prices and a contraction of credit. This induced a bear market where the price of a barrel of crude oil plummeted from $133.88 to $39.09 in less than a year. Asset prices across the globe experienced a downturn as credit tightened and earnings projections diminished. While oil prices were on the rise, the increased costs were swiftly passed on to consumers. However, when international prices began to decrease by the end of 2008, it took a considerable amount of time to transfer the cost-reduction benefits to consumers. Consequently, this led to reduced spending and increased unemployment, resulting in a decline in both consumer and business demand for oil (Değirmen, Tunç, Saltık & Rehman, 2023).

Following the rebound in global output during the financial crisis, economic growth was overestimated, resulting in excess oil production and supply. This misjudgment of future demand conditions significantly impacted prices and initiated the price collapse in 2014. The oil market collapsed due to the growing supply glut, which failed to deliver the anticipated boost to global growth. Notably, the significant increase in oil production, inventories, and consumption contributed to an outward shift in the supply curve. Additionally, the unexpected surge in shale oil production in the United States and decisions made by OPEC to maintain oil output further exacerbated the decline in oil prices.

The onset of the COVID-19 pandemic triggered a demand shock in the oil industry, leading to a collapse in prices. In 2020, global oil demand rapidly decreased as governments enforced business closures and travel restrictions to contain the spread of the virus (Figiel, Floriańczyk, & Wigier, 2023). Negotiations between Russia and the Organization of the Petroleum Exporting Countries (OPEC) to reduce daily oil production in response to the low demand failed, resulting in an oil price war between Saudi Arabia and Russia. This conflict intensified when there was no consensus on oil production levels in March. The oversupply of oil caused oil barrel prices to plummet to negative figures, with producers forced to pay buyers to take barrels they couldn't store. In response to low demand, OPEC and its allies slashed overall crude oil production by 9.7 million barrels per day. Oil prices plunged in the spring of 2020 due to fears of COVID-19 spreading and amid the price war, triggering a shock to global economic demand.

The Consumer Price Index (CPI) represents the price of a weighted average market basket of consumer goods and services purchased by households. It serves as a measure of the average change over time in the prices paid by urban customers for a market basket of consumer goods and services. Major components of the CPI include household operations, food/beverages, transportation, education, health, and personal care. While crude oil prices indirectly contribute to inflation, they are not included in the CPI due to their volatility. Governments utilize CPI data to set payments such as wages (Boskin, Dulberger, Gordon, Griliches & Jorgenson, 1998).

In Kenya, the CPI has risen to 131.18 points in March of this year compared to 130.13 points in February. Fuel oil, propane, kerosene, and firewood are priced in the same manner as other commodities in the consumer price index. To calculate inflation, the cost of a basket of goods each year is required. CPI excludes taxes on income and social security, as they are not directly associated with the purchase of consumer goods and services. Furthermore, CPI does not account for investment items such as stocks, bonds, real estate (REITs), life insurance, loans, second-hand goods, lotteries, and gambling expenditures, as no actual goods or services are purchased. Oil prices have a more significant impact on the cost of goods than services, explaining the weak correlation between oil and the consumer price index. However, there is a strong correlation between crude oil and the producer price index. An increase in oil prices results in higher inflation and reduced economic growth.

1.2 Statement of the Problem

Hydrocarbons are a strategic commodity that influences the economy of every nation, and their pricing often fluctuates due to external shocks. In Kenya, CPI is a measure of changes in prices paid by consumers for a basket of goods. The majority of these goods included in the basket are often partially tied to oil prices, either due to the presence of oil components in them or their reliance on petroleum for production and transportation. Thus, when oil prices increase, prices of many other goods increase, leading to an increase in CPI. This harms consumer spending power and the Gross Domestic Product growth at large. It is for these reasons that the Energy and Petroleum Regulatory Authority (EPRA) sometimes subsidizes oil prices. Data from the Kenya National Bureau of Statistics (KNBS) economic survey placed Kenya's total import bill for petroleum products at KSh. 348.3 billion in 2021 from Ksh. 209.1 billion in 2020. This is because there was a global increase in demand for petroleum products, leading to increased prices for Murban crude oil from USD 41.45 per barrel to USD 69.72 per barrel in 2021 (Economic Survey 2022, 2022). For consumers, this higher import bill was demonstrated by soaring prices for petrol, diesel and kerosene.

Later in the year 2021, EPRA removed fuel subsidies and paid petroleum providers compensation for keeping prices low for five months. For consumers, the effects of the removal of the subsidy were felt almost immediately. In a bid to lower our fuel import bill, Kenya will, as of April 2023, import oil on credit from the United Arab Emirates (Mutua, 2023). This is expected to reduce oil prices in Kenya, which will later reduce prices of commodities tied to these oil prices. Therefore, this research analyzes the prevailing conditions in the oil sector by forecasting prices of significant oil commodities and their effect on the Consumer Price Index, making reliable and well-informed guidelines on how the Kenyan oil sector and, consequently, the CPI can be stabilized.

1.3 Objectives of the Study

1.3.1 General objective

This study aims to determine the relationship between crude oil price fluctuations and CPI in Kenya.

1.3.2 Specific Objectives

The specific objectives of this study will be:

I. The purpose of this study is to determine the relationship between the Consumer Price Index (CPI) and the prices of the different major oil products in Kenya.

II. Forecast the Consumer Price Index and the prices of major oil products in the Kenyan oil sector for the next 18 months using a time series technique.

1.4 Research Questions

I. What is the relationship between the Consumer Price Index and the prices of major oil products in Kenya?

II. What will the CPI be, and what will the prices of major oil products in Kenya be for 18 months from the time of this study?

1.5 Significance of the Study

This research paper provides evidence of how oil price fluctuations impact our country's CPI and provides policy recommendations to mitigate the impact. The research is useful to the government, oil marketers, firms, and the general public.

The findings are helpful to the government, where the Ministry and Energy and Petroleum Regulatory Authority on measures and regulations that stabilize the industry and create healthy competition among oil marketers. Economic agents may use the analysis in planning purposes for their businesses as they can use future oil prices to predict the movements of CPI values in the country reliably. The research also helps firms (the manufacturing industry) to plan for their businesses appropriately; the general public, on the other hand, will be in a position to cushion themselves from oil price fluctuations and predict the expected future CPI values and Oil prices.

1.6 Scope of the Study

The oil industry in Kenya is the basis for this study. It focuses on the three major oil components, such as super diesel, petrol and kerosene, whose collected past data on prices from the period of January 2012 to March 2023 is used for forecasting. The study makes use of the Consumer Price Index (CPI) for all the commodities included within the basket to help make unbiased conclusions on the impact of oil prices on the economy in general.

2. LITERATURE REVIEW

2.1 Introduction

Theories abound in the economic literature on the relationship between oil prices and the Consumer Price Index. In the first section, an attempt is made to briefly review related theories to give this research a theoretical base. Three theories were examined: the cost-push inflation theory, the demand-pull inflation theory and the theory of production. In the subsequent sections, there are discussions on the empirical review related to the research questions and the critique of evidence from related studies worldwide.

2.2 Theoretical Review

2.2.1 Cost-Push Inflation Theory

The cost-push inflation theory is a Keynesian Model that occurs when there is an overall increase in prices of various commodities due to the rise in their costs of production. Inflation can diminish a consumer's purchasing power if earnings do not rise sufficiently to keep pace with increasing prices (Wikimedia Foundation, 2023).

Commodities whose production is based heavily on oil are more vulnerable to price changes. In the early 1970s, the Organization of Petroleum Exporting Countries imposed an oil embargo on various countries, including the United States. They banned oil export to countries they were targeting and imposed cuts on their oil production rate, leading to what is famously known as the supply shock and a dramatic increase in oil prices from approximately $3 to $12 per barrel (Knittel, 2014). This led to cost-push inflation since demand did not increase, and this surge in barrel prices led to higher production costs for companies with petroleum-based products, thus prompting them to increase their product prices.

This theory is thus relevant to this study as it uses a cost approach to explain the cause of inflation, measured using CPI. The costs of production encompass several things, such as an increase in the cost of wages, taxes and raw materials. An increase in any is passed on to consumers through higher product prices. In turn, the aggregate changes in different product prices are realized through the rise and fall in CPI.

2.2.2 Demand-Pull Inflation Theory

This theory suggests that when the aggregate demand increases at a quicker rate than the available supply, the result is higher prices, leading to inflation. According to Keynesian economics, an increase in aggregate demand can be caused by decreased unemployment, as companies need more human resources to increase output. A tight labour market will lead to a rise in wages and, later, an increase in demand (Johnson, 2017). The difference between cost-push and demand-pull inflation theories is that supply costs drive the former. In contrast, the latter is driven by demand from consumers, and in the end, both result in a rise in product prices passed on to consumers (Schwarzer, 2018).

This theory is a principle of Keynesian economics and refers to the effects of an imbalance between aggregate supply and aggregate demand. During an economic boom, the employment rate increases as producers hire more to produce more. This means that wages will be pushed up as demand for labour continues to increase. A rise in wages translates to a rise in disposable income; hence, consumers gain the ability to spend and demand more. Eventually, the demand for various goods will not match their supply. Rising real wages, reduced interest rates, and increased government spending in a growing economy are significant causes of demand-pull inflation (Pettinger, 2021).

The Demand-pull inflation theory is relevant to this study in that it uses the purchasing power of consumers as a cause of inflation, which in turn is measured through changes in the CPI. Through this theory, we can predict the uniformity of changes in prices of major oil products as it points out that these changes usually occur during periods of economic boom, which are easily identifiable through the observation of various determining factors.

2.2.3 Theory of Production

The theory of production is an effort to explain the principles by which a business firm decides how much of each commodity it will sell and produce and how much of each kind of factor input or production factor it will use (Dorfman,1951). It involves some of the most fundamental principles of economics, such as the correlation between the prices of commodities and prices of the production factors used in production. It also describes the relationships between the prices of commodities and production factors, on the one hand, the quantities of these commodities, and the production factors used/produced on the other hand. In other words, it describes the correlation between the input costs and the output levels in an economy. It has an inverse relationship, implying that output levels decline as input costs rise ceteris paribus. Since the main motive of any business firm is profit maximization, their profit levels depend on the input costs of the commodities being produced, the overall production levels, and the price levels of their outputs.

2.3 Critique of the Existing Literature Relevant to the Study

The studies bring out the relationship between oil prices, CPI, inflation, and other economic variables. The findings from the survey largely support the idea that oil prices affect inflation rates, with some indicating a considerable effect in the long run. However, the extent and significance of the link vary across different nations and periods. Additional variables, such as market power, regulatory policies, interest rates, and the type of oil shock, are also acknowledged in the studies to have an impact on the relationship between oil prices and economic variables. This recognition highlights the topic's complexity; hence, more research is needed to capture the dynamics of this relationship to provide more insight to various stakeholders. The majority of the works cited did not examine the effect of the prices of individual crude oil products on the CPI. This is the critical gap that this study will cover through its emphasis on super petrol, diesel, and Kerosene.

3. RESEARCH METHODOLOGY

3.1 Research Design and Target Population

The research methodology serves as a pivotal guide for researchers, clearly describing the path required to conduct their investigations comprehensively. It encompasses various facets such as research design, target population, sampling techniques, data collection instruments and procedures, and data processing and analysis, which are all crucial for the successful execution of the study. The research design employed in this study was casual, specifically secondary research or desk research, which entails the utilization of existing secondary data meticulously compiled and arranged by other researchers. Leveraging data repositories such as the Kenya National Bureau of Statistics (KNBS) and the Energy and Petroleum Regulatory Authority (EPRA) ensures efficiency and access to extensive datasets amassed over a significant period, facilitating comprehensive analysis. The study's population of interest primarily encompasses the Kenyan populace, with a specific focus on individuals residing within the country's borders. Despite global changes affecting various aspects related to oil and the Consumer Price Index (CPI), the research aims to scrutinize fundamental consumption patterns, CPI fluctuations, and their relationship with fluctuating oil prices within the Kenyan context.

3.2. Sampling Frame and Sample Size

To ensure representation and comprehensiveness, the sampling frame comprises monthly price data for oil products and CPI spanning from January 2012 to March 2023, totalling 135 months. This duration was selected to facilitate continuous research on the subject matter, given the absence of studies conducted during this specific period. The meticulous selection of the sample frame lays the foundation for robust data analysis and interpretation. Moreover, the determination of the sample size was critical in this research since it directly impacts the accuracy and representativeness of the findings. For this study, monthly average crude oil prices in Kenya and CPI data over eleven years and three months were deemed sufficient. This timeframe provided ample data to establish statistically reliable links between oil prices and CPI, ensuring the credibility and validity of the research outcomes.

3.3.Data Collection Procedure

The data collection process involved gathering monthly price data for the primary types of crude oil, namely Super petrol, Diesel, and Kerosene, as well as monthly data for the Consumer Price Index (CPI) spanning from 2012 to March 2023. Specifically, the monthly CPI values were electronically retrieved from the Kenya National Bureau of Statistics, while the monthly oil prices were sourced from the Energy and Petroleum Regulatory Authority.

3.4.Data Processing and Analysis

The data analysis process of this study required the use of R studio for time series data. Descriptive analysis was carried out, pre-estimation such as the assumptions of regression, that is, normality using Shapiro Wilk test, heteroscedasticity using the Breusch Pagan test, autocorrelation using the Breusch Godfrey test, then the data was transformed into time series data for analysis. A unit root test was then conducted before doing a cointegration test, which was later concluded by building a Vector Error Correction Model (VECM). VECM adjusts to both short-run changes in variables and deviations from equilibrium. The model is denoted as

$$\Delta Y_t = \pi X_{t-1} + \sum_{l=1}^{p-1} \Gamma l\, \Delta x_{t-1} + Cd_t + \varepsilon_t$$

Where Δx is the first difference of the variables in vector x, π is a coefficient matrix of cointegration relationships, Γ is a coefficient matrix of the lags, d is a vector of deterministic terms, and C its corresponding coefficient matrix p is lag order of the model in its VAR form, and ε is a white noise error term. πX_{t-1} is the error correction term which captures how the CPI value changes if one of the variables departs from its equilibrium value. In the analysis of the cointegration test, the long-run relationship will be tested using the VECM model presented:

$$CPI_t = \beta_o + \beta_1 Diesel_t + \beta_2 Super\ petrol_t + \beta_3 Kerosene_t + \varepsilon_t \qquad 3.7.2$$

Where β_s: Model parameters, t: Time series, ε_t: Random error.

4. RESEARCH FINDINGS AND DISCUSSION

This chapter presents the results and findings of the analysis concerning the specific research objectives. The findings are presented in tabular formats, and discussions are held on particular objectives. This chapter presents descriptive statistics, tests for the assumptions of the classical average linear regression model (CNLRM), stationarity test, lag selection criterion, cointegration test, and post-estimation test. The chapter further presents the findings of the models adopted to achieve the study's objective.

4.1 Descriptive Statistics

The descriptive statistics presented in Table 1 provide a comprehensive overview of four key variables: CPI, Super petrol, Diesel, and Kerosene. Each variable's distribution and central tendency are clearly illustrated through measures such as minimum, maximum, quartile, median, and mean values. For instance, the Consumer Price Index (CPI) exhibits a moderate range of variation with a median value of 93.81 and a mean of 94.17, indicating a relatively symmetrical distribution. In contrast, Super petrol demonstrates a broader range of values, with a higher mean and maximum value compared to CPI, suggesting more significant variability in prices. Diesel, with values closer in range to CPI but slightly higher mean and median values, indicates a moderate level of variability. On the other hand, Kerosene displays a notable range of variation with comparatively lower mean and median values. These descriptive findings are instrumental in discerning the underlying dynamics and trends within the datasets of CPI, Super petrol, Diesel, and Kerosene. Such insights can facilitate informed decision-making processes and further analytical endeavours within the field of economics, energy markets, and policy formulation, aiding stakeholders in navigating and responding to fluctuations and patterns within these essential variables.

Table 1. Descriptive Statistics

Variable	Obs	Min	1QTR	Median	Mean	3QTR	Max
CPI	135	66.79	77.71	93.81	94.17	108.42	131.18
Super petrol	135	80.71	100.38	110.20	112.87	116.24	179.30
Diesel	135	65.70	88.98	102.24	101.52	106.91	165.00
kerosene	135	39.62	66.69	83.73	85.60	106.86	147.94

4.2 Test of the assumptions of CNLRM

Table 2 presents the outcomes of statistical assessments conducted on four variables: Super petrol, Diesel, Kerosene, and CPI. Each variable underwent a Shapiro-Wilk Normality Test to evaluate if its data adhered to a normal distribution. The results revealed that for all variables, including Super petrol, Diesel, Kerosene, and CPI, the Shapiro values fell below the critical threshold of 0.05, leading to the rejection of the null hypothesis of normality. Consequently, it was established that the data for these variables significantly deviated from a normal distribution, suggesting potential implications for analyses relying on normality assumptions. Following this, the Test for Heteroscedasticity was employed to examine the consistency of variance across different levels or groups within the data. While the specific variable under consideration was not explicitly mentioned, the obtained p-value was below

0.05, indicating the presence of heteroscedasticity and necessitating careful consideration in subsequent analyses to account for unequal variances.

Additionally, the table provided insights from the Test for Autocorrelation, which aimed to identify correlations among observations of a variable at different time points. Despite the absence of specific variable references, the low p-value obtained indicated a rejection of the null hypothesis of no autocorrelation. This finding hinted at the presence of autocorrelation within the data, suggesting potential dependencies among consecutive observations that could influence the accuracy of statistical inferences. Collectively, these statistical assessments highlighted significant departures from critical assumptions such as normality, homoscedasticity, and lack of autocorrelation, necessitating cautious interpretation of subsequent analyses and potentially prompting the adoption of alternative statistical approaches to ensure robust results.

Table 2. Normality Heteroscedasticity, Autocorrelation tests

Test for Normality			
Variable	**Shapiro-value**	**p-value**	**Decision**
Super petrol	0.83642	5.999×10^{-11}	Reject H_0
Diesel	0.85756	4.467×10^{-10}	Reject H_0
kerosene	0.94924	7.201×10^{-5}	Reject H_0
CPI	0.95479	2001.000×10^{-4}	Reject H_0
Test for Heteroscedasticity			
Bp	**Df**	**p-value**	**Decision**
31.507	3	6.648×10^{-7}	Reject H_0
Test for Autocorrelation			
LM test	**Df**	**p-value**	**Decision**
90.344	1	2.2×10^{-16}	Reject H_0

To assess the stationarity of the series, monthly values of CPI, diesel, kerosene, and super petrol from January 2012 to March 2023 were examined using time series plots depicted in Figures 1, 4, 6, and 8. The analysis conclusively indicates that the series were non-stationary, as previously determined through the augmented Dickey-Fuller test. Furthermore, to determine the model order, Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) plots were generated and are presented in Figures 2, 4, 6, and 8.

ACF and PACF plots

Figure 1. Monthly CPI Values from January 2012 to March 2023

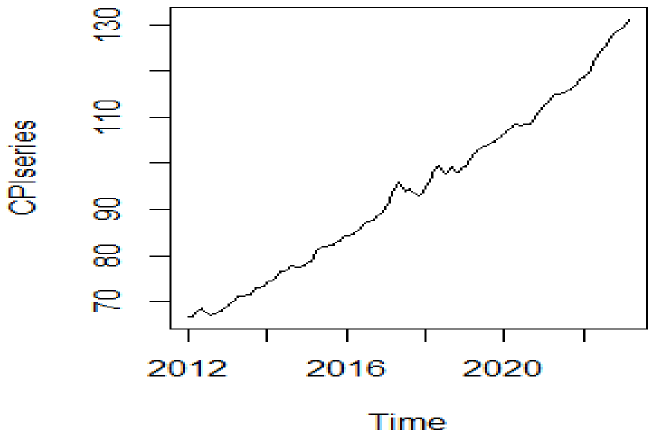


Figure 2. ACF and PACF of CPI

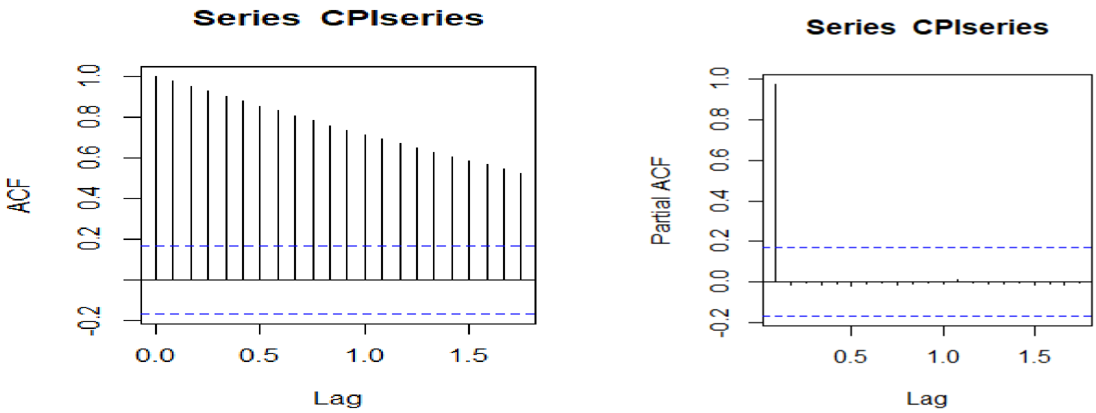


Figure 3. Monthly Superpetrol values from Jan 2012 to Mar 2023

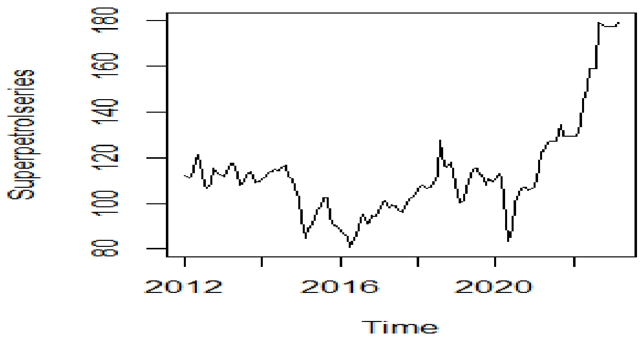


Figure 4. ACF and PACF of Super Petrol

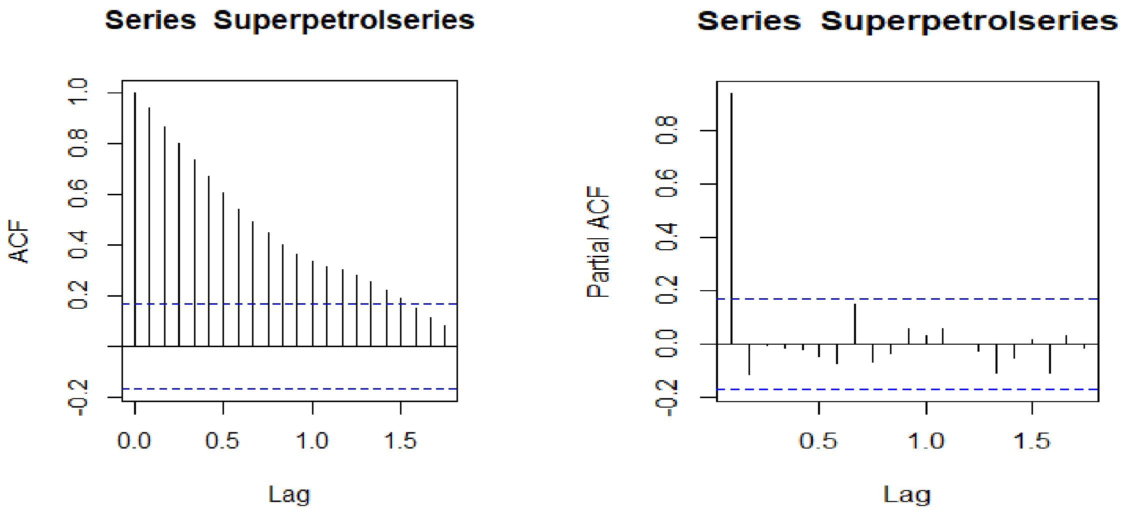


Figure 5. Monthly Diesel Values from Jan 2012 to Mar 2023

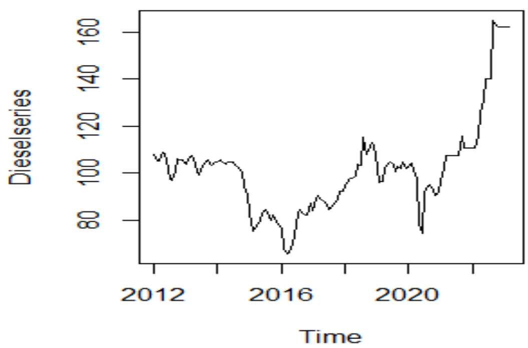


Figure 6. ACF and PACF of Diesel

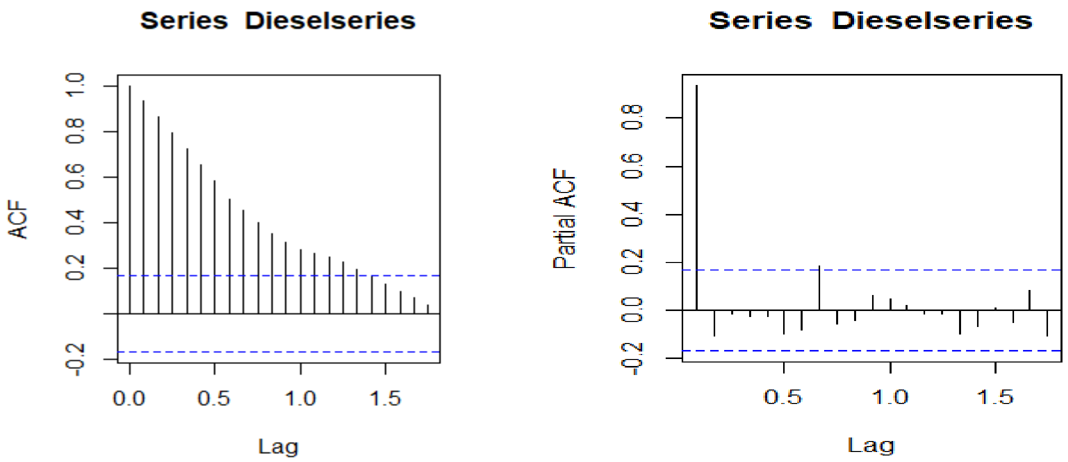


Figure 7. Monthly Prices of Kerosene from Jan 2012 to Mar 2023

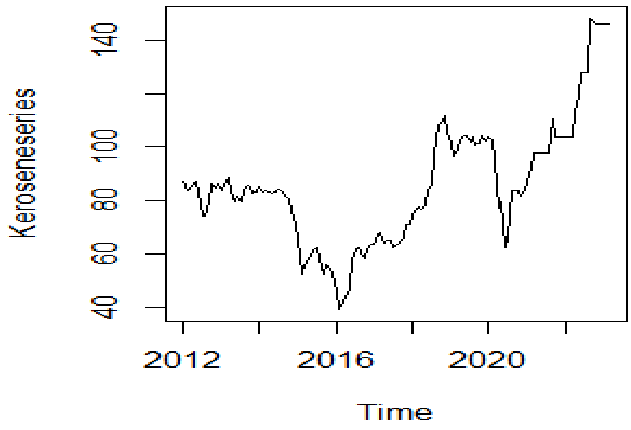
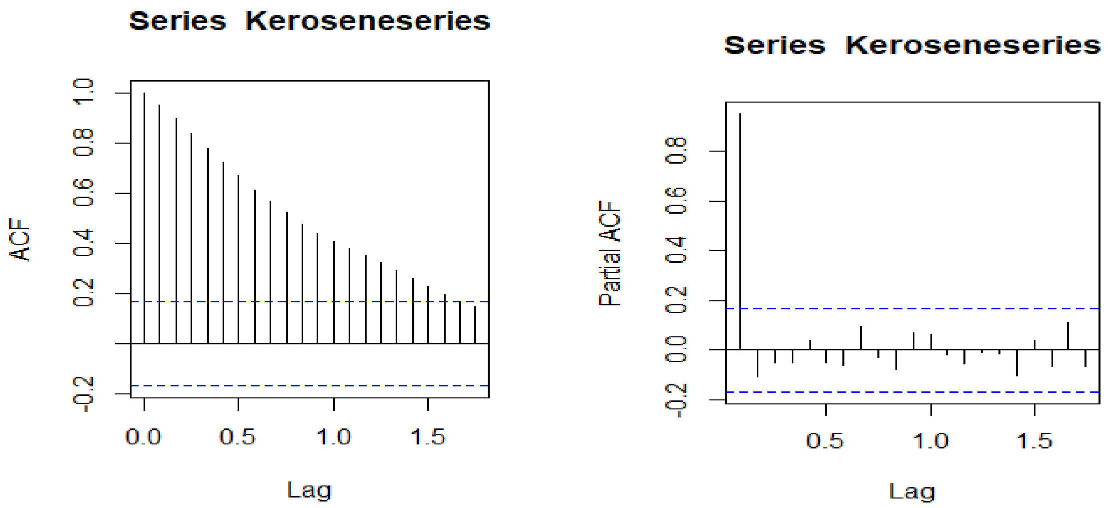


Figure 8. ACF and PACF of Kerosene



4.3 Unit Root test (Augmented Dickey-Fuller)

Table 3 suggests that CPI value, Super petrol, Diesel, and Kerosene variables, the ADF was conducted as indicated by Yodah et al. (2013) among other scholars. The test statistics were -0.57543, -0.15886, -0.72025, and -1.2077, respectively. The p-values associated with these statistics were 0.9772, 0.99, 0.9665, and 0.9023, respectively. The null hypothesis in the ADF test was that the series contained a unit root, indicating non-stationarity. The decision whether to reject the null hypothesis was based on the significance level, typically set at 0.05. In this case, all p-values were more significant than the significance level of 0.05. Therefore, for each variable, the decision was to fail to reject the null hypothesis. This implied that there was insufficient evidence to conclude that the series was stationary. In other words, the variables exhibited non-stationary behaviour, suggesting the presence of a unit root.

Table 3. Augmented Dickey-Fuller Test

Variable	ADF test statistics	p-value	Decision
CPI value	-0.57543	0.9772	Fail to reject the null hypothesis
Super petrol	-0.15886	0.99	Fail to reject the null hypothesis
Diesel	-0.72025	0.9665	Fail to reject the null hypothesis
Kerosene	-1.2077	0.9023	Refrain from rejecting the null hypothesis.

Table 4 demonstrates the process of selecting lags based on four distinct information criteria: the Akaike Information Criterion (AIC), the Hannan-Quinn criterion (HQ), the Schwarz Criterion (SC), and the Final Prediction Error (FPE). Each criterion suggests a particular number of lags denoted as 'n'. The AIC criterion suggests including three lags, the HQ criterion recommends two lags, the SC criterion indicates one lag and the FPE criterion suggests three lags. Lag selection plays a pivotal role in time series analysis, directly influencing the effectiveness of models and the accuracy of forecasts. Consequently, considering the results from the table, where three emerged as the most frequently recommended number of lags by both the AIC and FPE criteria, it was determined to utilize three lags as the maximum number. However, it's worth noting that when employing the Vector Error Correction Model (VECM), one lag must be omitted (Awad, 2017). Hence, the VECM model utilized in this study opted for two lags.

Table 4. Lag Selection

AIC (n)	HQ (n)	SC (n)	FPE (n)
3	2	1	3

4.4 Johansen Cointegration Tests Using Maximum Eigen Value and Trace Statistic

The Johansen Cointegration Tests were employed using both the Maximum eigenvalue and Trace Statistic methodologies to determine the presence and number of cointegrating vectors in a set of time series data. Cointegration, implying a long-term equilibrium relationship among variables, was crucial for understanding their interdependencies and dynamics. In the Maximum Eigen Value test, various hypotheses regarding the number of cointegrating vectors (r) were tested against alternative hypotheses. For each hypothesis, a test statistic was computed along with critical values at different significance levels (10%, 5%, and 1%). If the computed test statistic exceeded the critical value, the null hypothesis was rejected, indicating the presence of cointegration. However, if the test statistic fell below the critical value, the null hypothesis failed to be rejected, suggesting no evidence of cointegration. In the provided results, all hypotheses were unable to reject the null hypothesis, indicating the absence of cointegration.

Similarly, the Trace Statistic test evaluated hypotheses regarding the number of cointegrating vectors using a different approach. Here, the trace statistic was computed for each hypothesis, and critical values were compared to determine whether the null hypothesis should be rejected. As with the Maximum Eigen Value test, the results indicated a failure to reject the null hypothesis for all hypotheses, suggesting no evidence of cointegration. Overall, these tests provided insights into the relationship among variables in the time series data. The failure to reject the null hypothesis in both tests suggested that the variables were not cointegrated, implying they did not share a long-term equilibrium relationship. This information was essential for selecting appropriate modelling techniques and interpreting the dynamics of the data accurately.

Table 5. Johansen Cointegration Tests Using Maximum Eigen Value and Trace Statistic

Johansen Cointegration Tests Using Maximum Eigen Value						
H0	H1	test	10pct	5pct	1pct	Decision
r<=3	r>3	4.55	10.49	12.25	16.26	Fail to reject H0
r<=2	r>2	10.96	22.76	25.32	30.45	Fail to reject H0
r<=1	r>1	34.12	39.06	41.44	48.45	Fail to reject H0
r=0	r>0	73.27	59.14	62.99	70.05	Reject H0
Johansen Cointegration Test Using Trace Statistic						
H0	H1	test	10pct	5pct	1pct	Decision
r=3	r=4	4.55	10.49	12.25	16.26	Fail to reject H0
r=2	r=3	6.41	16.85	18.96	23.65	Fail to reject H0
r=1	r=2	23.16	23.11	25.54	30.34	Fail to reject H0
r=0	r=1	39.15	29.12	31.46	36.65	Reject H0

4.5 Vector Error Correction Model

The vector error correction model (VECM) was utilized to analyze the relationship between multiple variables over time, based on a set of variables including the Consumer Price Index (CPI), Super series, Diesel series, and Kerosene series. The model was characterized by its number of variables, estimated slope parameters, and model fit statistics such as the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and the sum of squared residuals (SSR), which provided insights into the model's goodness of fit and complexity. Moreover, the cointegrating vector estimated by 20-lag least squares (20LS) indicated the long-term equilibrium relationships among the variables. At the same time, the error correction terms (ECT) and coefficients for each equation within the model illustrated the short-term dynamics of the variables and their adjustment towards equilibrium following deviations from the long-term relationship.

Overall, the VECM served as a comprehensive analytical tool for studying the dynamics and relationships among multiple time series variables. By considering both short-term dynamics and long-term equilibrium relationships, the model provided valuable insights into the behaviour of the variables, facilitating informed decision-making in various analytical contexts.

Table 6. Vector Error Correction Model

Full sample size: 135 End sample size: 132
Number of variables: 4 Number of estimated slope parameters: 40
AIC 799.4643 BIC 923.4248 SSR 7674.495
Cointegrating vector (estimated by 20LS):

	CPI series	Diesel series	Super series	Kerosene series
r1	1	1.69081	-1.999778	-0.4498129

	ECT	Intercept	Cpi series	Diesel series	Super Series	Kerosene series
Equation CPI Series	-5.7e-06(0. 0028)	0. 2873(0. 0572) ***	0. 6272(0. 0874)	0.0019(0.0 163)	0.0327 (0.0150) *	-0.0182(0.012 1)
Equation Diesel series	0.0173(0.0 271)	-0.0390(0. 5552)	0.1021(0. 8477)	-0.3566(0.1 583)*	0.4225(0.1 452)**	0. 2477(0.1171) *
Equation Super Series	0.0443(0.0 277)	-0.1331(0. 5669)	0. 0181(0. 8656)	-0.1518(0.1 616)	0. 2765(0.14 83).	0.1819(0.119 6)
Equation Kerosene Series	0.0308(0. 0291)	0.4657 (0. 5949)	0. 2644(0. 9083)	0.4347(0.5 949)	0.0455(0.1 556)	-0.0975(0.125 5)

	CPI Series	Diesel series	Super Series	Kerosene Series
Equation CPI Series	-0. 2283(0. 0861)	0.0210(0. 0176)	-0. 0383(0. 0160)	0.0059(0. 0110)
Equation Diesel series	0.4817 (0. 8350)	-0. 3784(0.17 07)	0.0503(0.1 550)	0.2557(0.1 066)
Equation Super Series	0.9229(0. 8526)	-0.0112(0.1 743)	-0. 2585(0.15 83)	0.1917(0.1 088).

From the above table 8, for both lag 1 and 2, the ECT is not significant, which implies that the disequilibrium cannot be corrected to equilibrium in the long run. All the variables had a short-run relationship with themselves in both the two lags. The results further show that in the cointegrating equation, CPI had a positive relationship with diesel and a negative relationship with both kerosene and super petrol. The cointegrating equation with normalized coefficients for CPI can be expressed in the given equation below:

$CPI_t = 0.2873 + 1.69081DS_t + 1.999778SP_t + 0.4498129KS_t$

where: $\mathbf{DS_t}$ is diesel series at time t, $\mathbf{SP_t}$ is super petrol series at time t, and $\mathbf{KS_t}$ is kerosene series at time t

4.6 Forecasted values

Based on the VECM fitted above, Figures 10, 11, and 12 display the projected values for the Consumer Price Index (CPI), diesel series, super petrol series, and kerosene series over time.

Figure 10. Forecasted Values for CPI

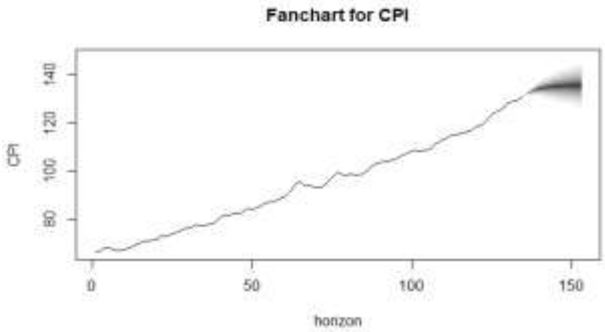


Figure 11. Forecasted Values for Diese

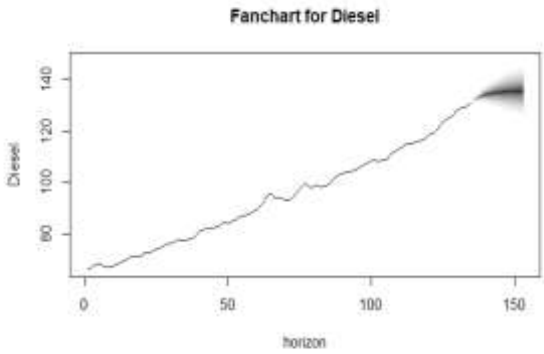


Figure 12. Forecasted Values for Super Petrol

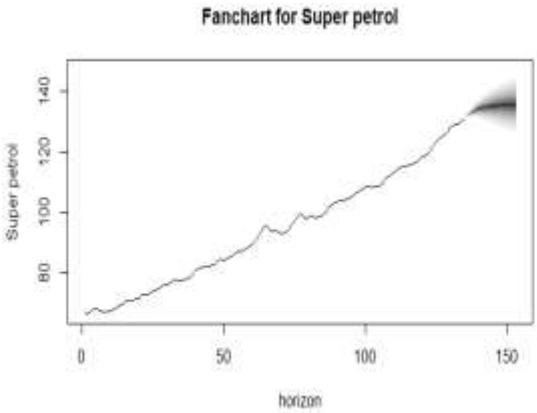
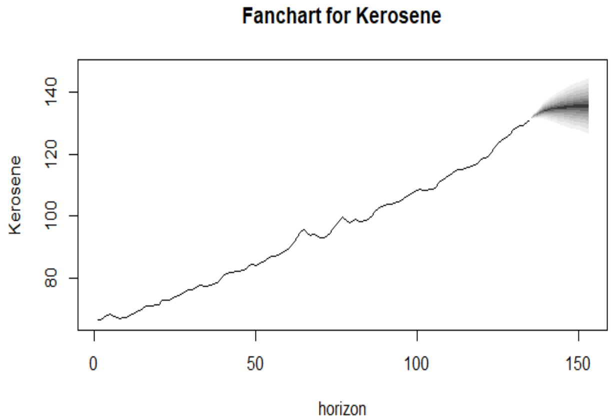


Figure 13. Forecasted Values for Keros



The above results show that, as observed in the data, the increasing trend in the values of the variables is expected to remain the same for the next 18 months.

4.7 Adequacy of the Model

The p-values in the above table are compared against a 0.05% level of significance, which concludes that the model was adequately fitted.

Table 7. Test for Adequacy of the Model

Test	Test statistics	p-value	Conclusion
Jacque-Bera	632.08	2.2×10^{-16}	Not Normally distributed
ARCH-LM	483.71	8.737×10^{-11}	No Homoscedasticity
Portmanteau	50.819	0.0001689	Serial correlation

4.8 Impulse Response

According to the impulse response functions as indicated in Figures 14, 15, 17, and 18, CPI values exhibit a gradual response to variations in diesel but a prompt response to changes in both super petrol and kerosene. This suggests that fluctuations in diesel, kerosene, and super petrol will likely result in corresponding fluctuations in CPI. Similarly, fluctuations in diesel, super petrol, and kerosene are expected to manifest in their future values.

Figure 14. Impulse response of CPI to Diesel and Super Petrol

Figure 15. Impulse Response of Diesel to Diesel and CPI to Kerosene

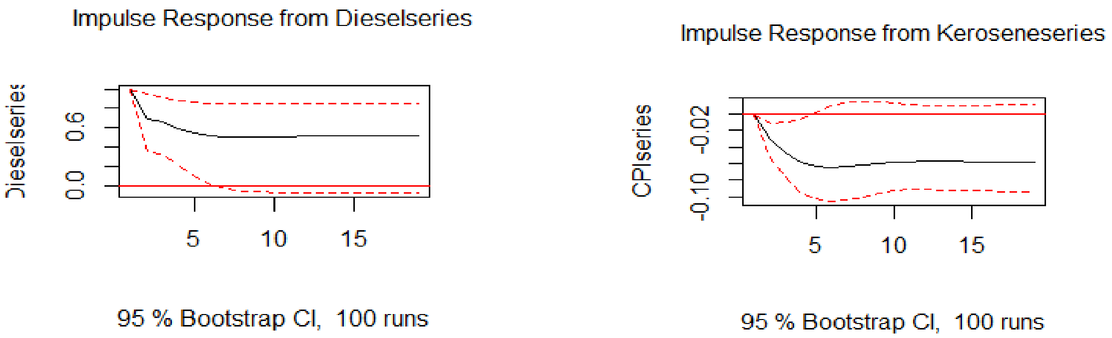


Figure 16. Impulse Response of CPI to CPI and Petrol to Petrol

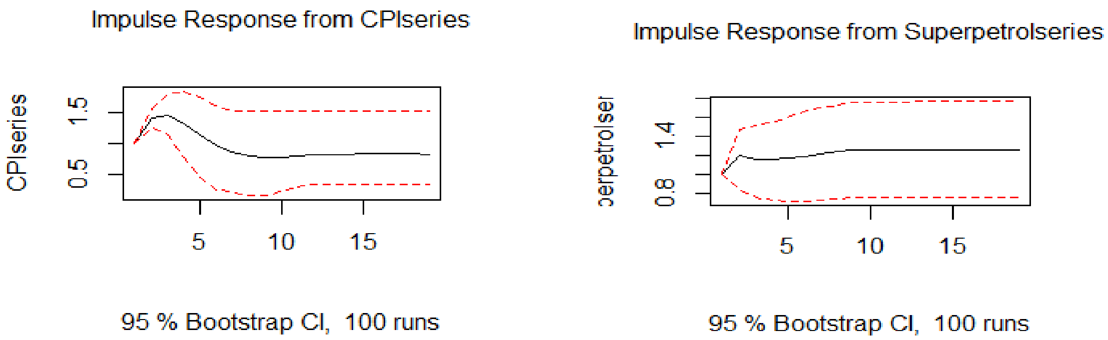
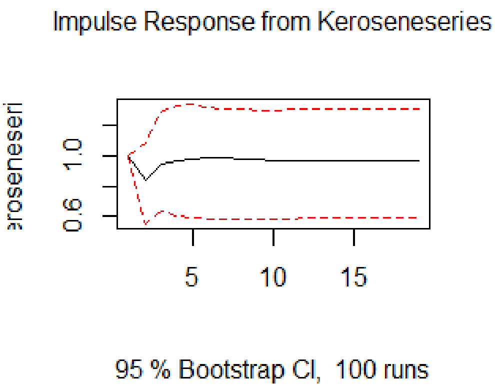


Figure 17. Impulse Response of Kerosene to Kerosene



5. CONCLUSION

Based on observations from the CPI and oil product forecasts, it is evident that the values align with the expected market behaviour of the variables under examination. Consequently, the public should prepare for an increase in oil prices and a rise in CPI values in the short term. Furthermore, the study indicates the presence of a long-term relationship between CPI and significant types of crude oil.

Given their significant impact on the overall economy and their extensive use in various sectors, such as manufacturing, it is recommended that oil products be given greater weighting in CPI calculations. To mitigate overreliance on fossil fuels, the government should prioritize the exploration and utilization of alternative energy sources.

To ensure stability and enhance market predictability, the Energy and Petroleum Regulatory Authority (EPRA) should establish a monitoring mechanism for fluctuations in oil commodity prices within the national economy. Additionally, EPRA should devise strategies that benefit local consumers and prevent oil marketers from exploiting them.

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